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Sugimoto et al.

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(54) **ELECTRIC STEERING LOCK DEVICE**

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B60R 25/0215 (2013.01)

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CPC ***B60R 25/0215*** (2013.01)

(58) **Field of Classification Search**
CPC Y10T 70/5956; Y10T 70/5664; Y10T 70/5646; Y10T 70/565; Y10T 70/5655;
(Continued)

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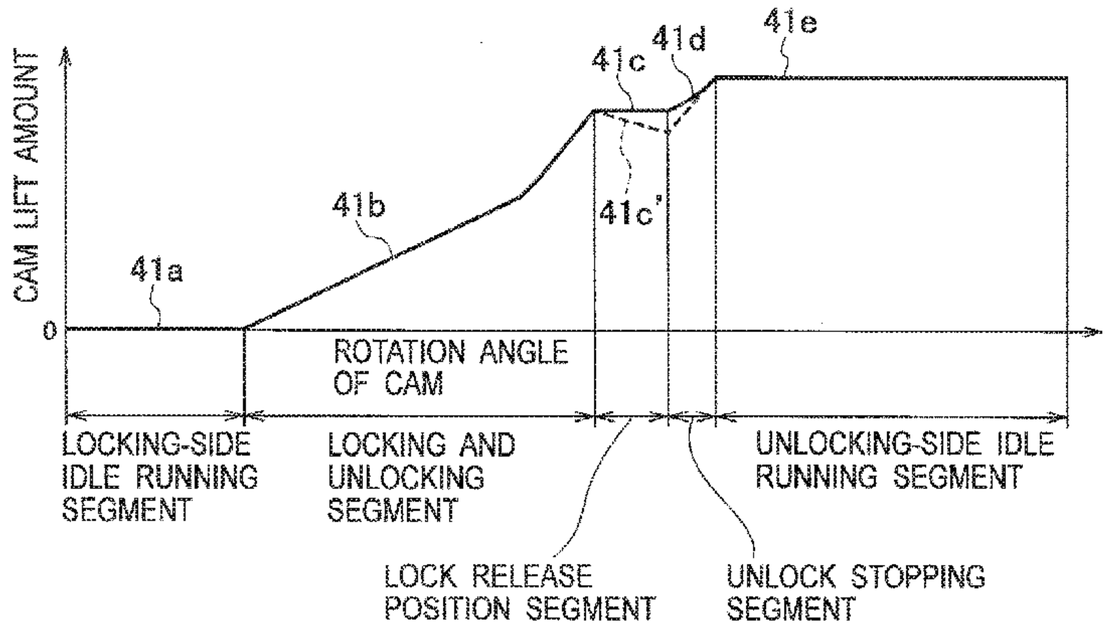
(57) **ABSTRACT**

The electric steering lock device (**1**) is provided with a cam (**40**) which is arranged to allow forward and reverse rotation inside of a frame (**10**), and a lock member (**50**) which, while following a cam surface (**41**) of the rotating cam (**40**), is arranged to be movable forward and backward between a locked position at the advancing end and an unlocked position at the retreating end. The cam face (**41**) comprises a locking and unlocking segment (**41***b*) for moving the lock member (**50**) and a lock release position segment (**41***c*). A change ratio of a cam lift amount to a rotation angle of the cam (**40**) in the lock release position segment (**41***c*) is constructed to be smaller than the change ratio of the can lift amount to the rotational angle of the cam (**40**) in the locking and unlocking segment (**41***b*).

5 Claims, 12 Drawing Sheets



(58) **Field of Classification Search**
CPC Y10T 70/5659; B60R 25/02153; B60R 25/0211; B60R 25/021; B60R 25/0215; B62D 1/184; B62D 1/16
USPC 70/182–186, 252
See application file for complete search history.

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FIG. 1

(Prior Art)

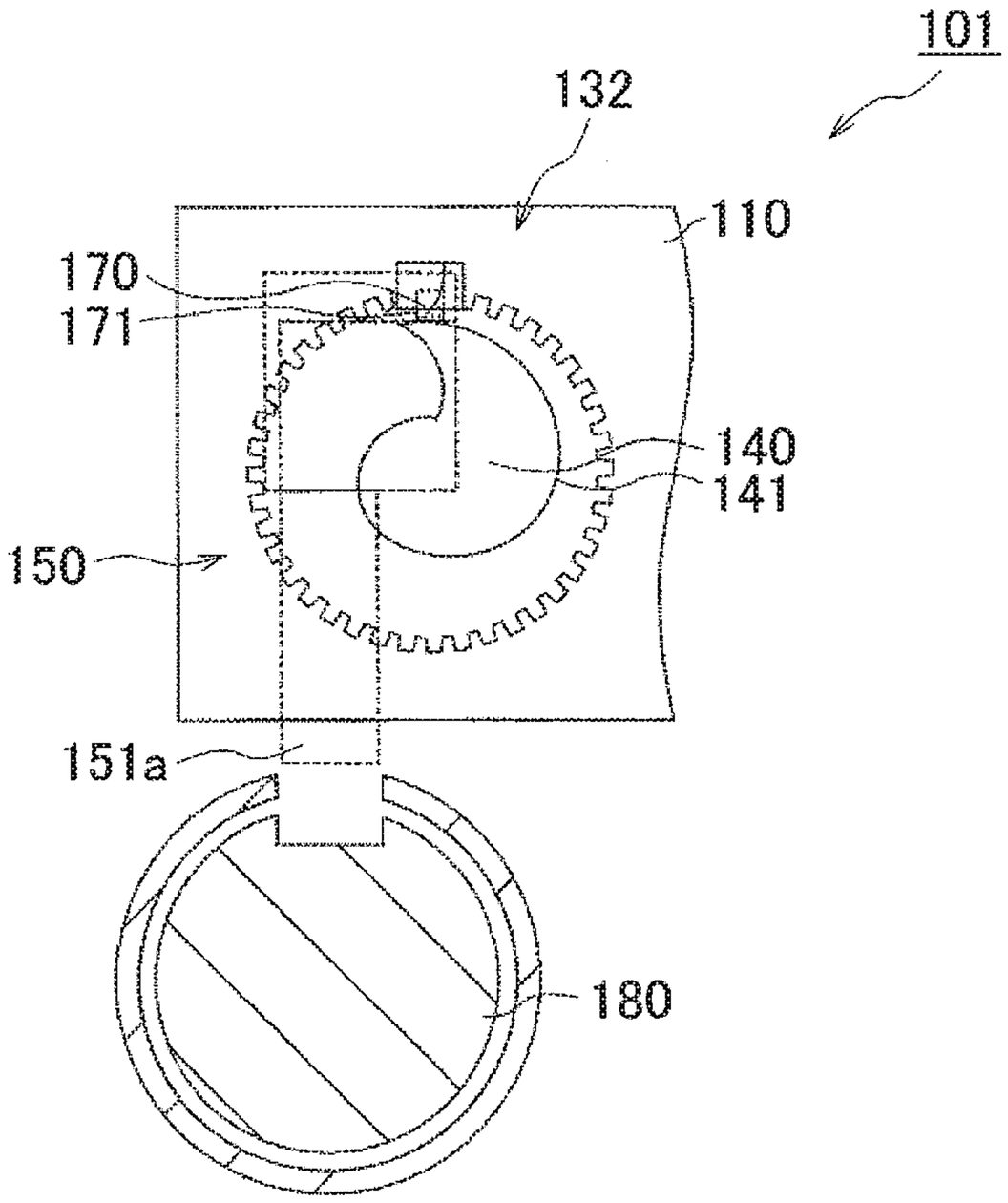


FIG. 2

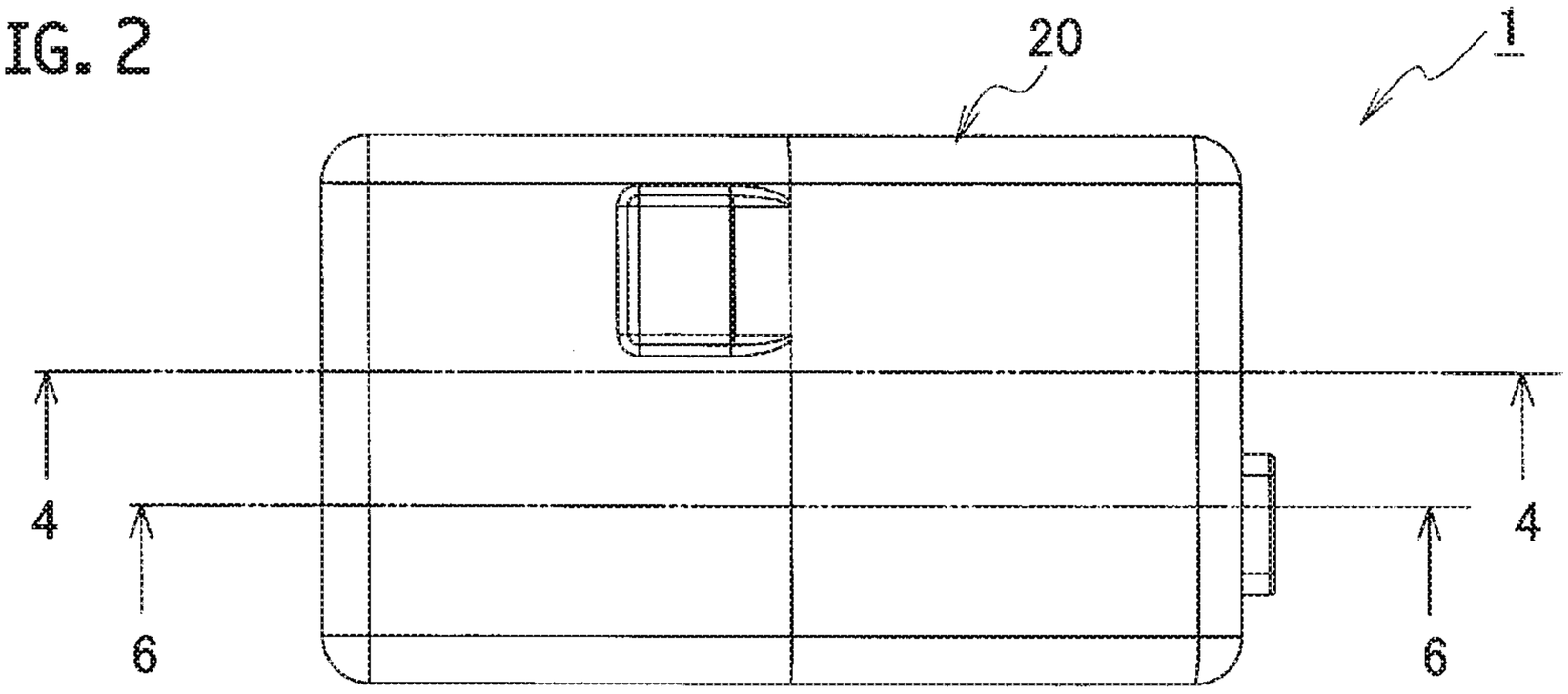


FIG. 3

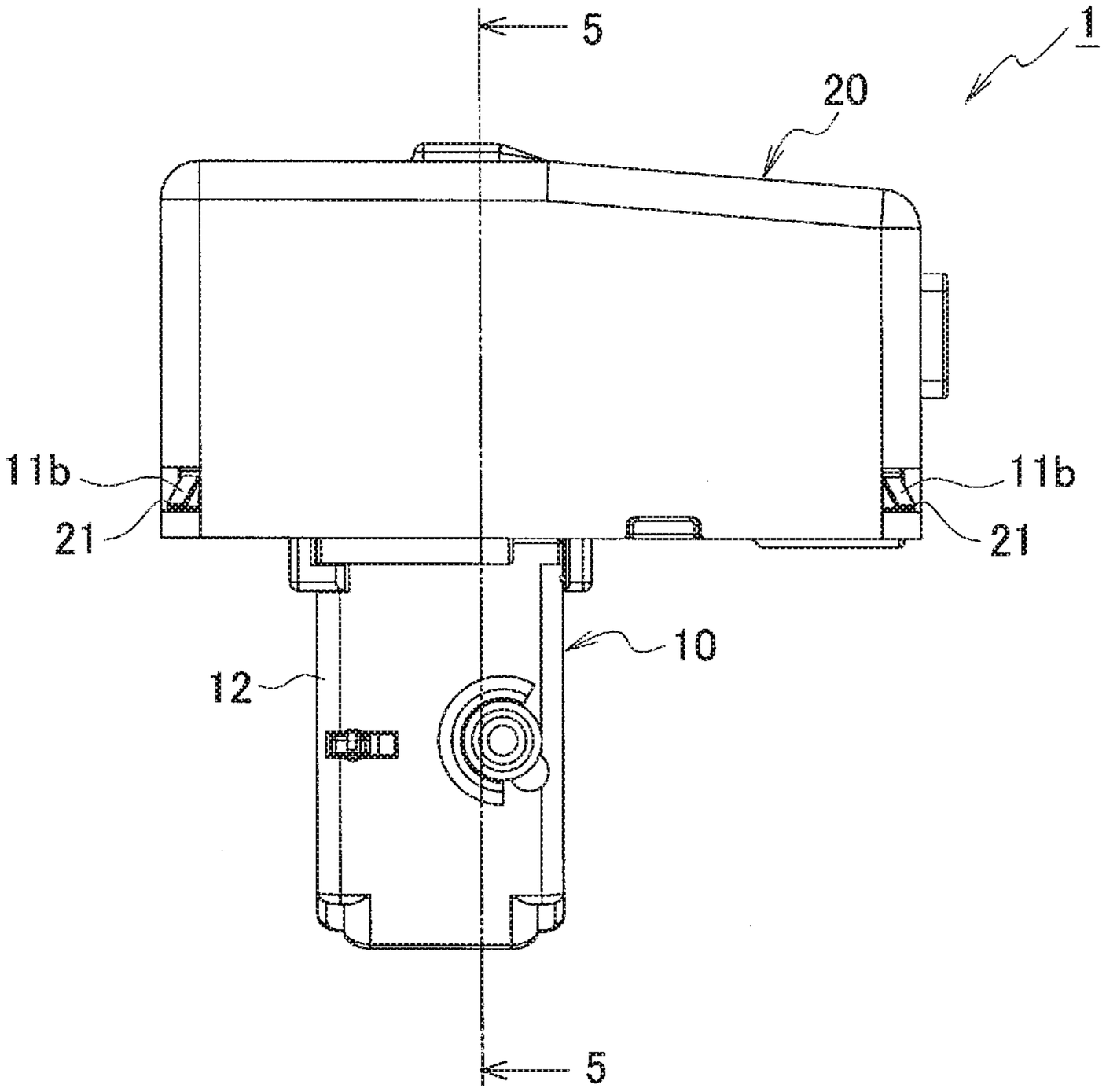


FIG. 4

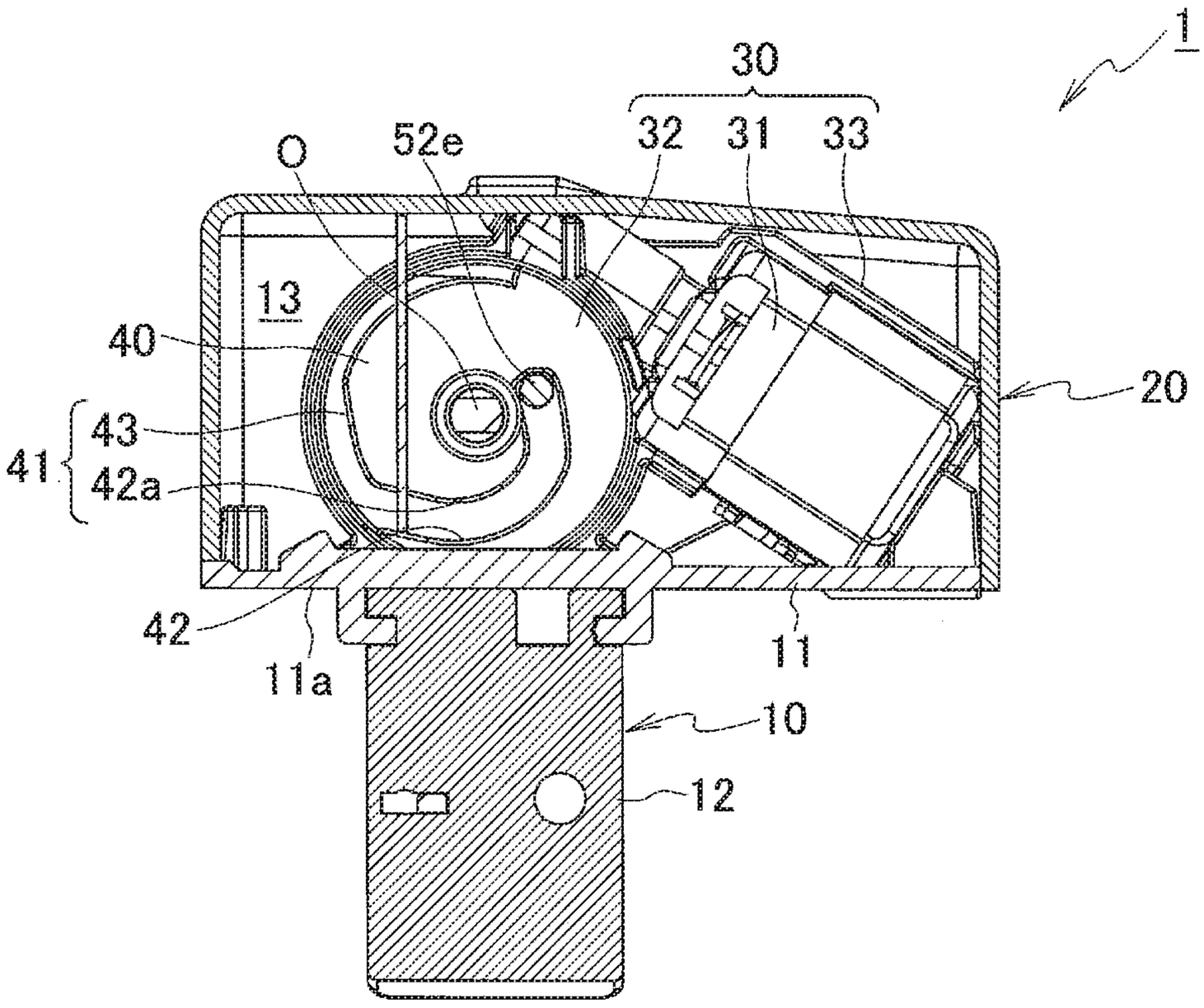
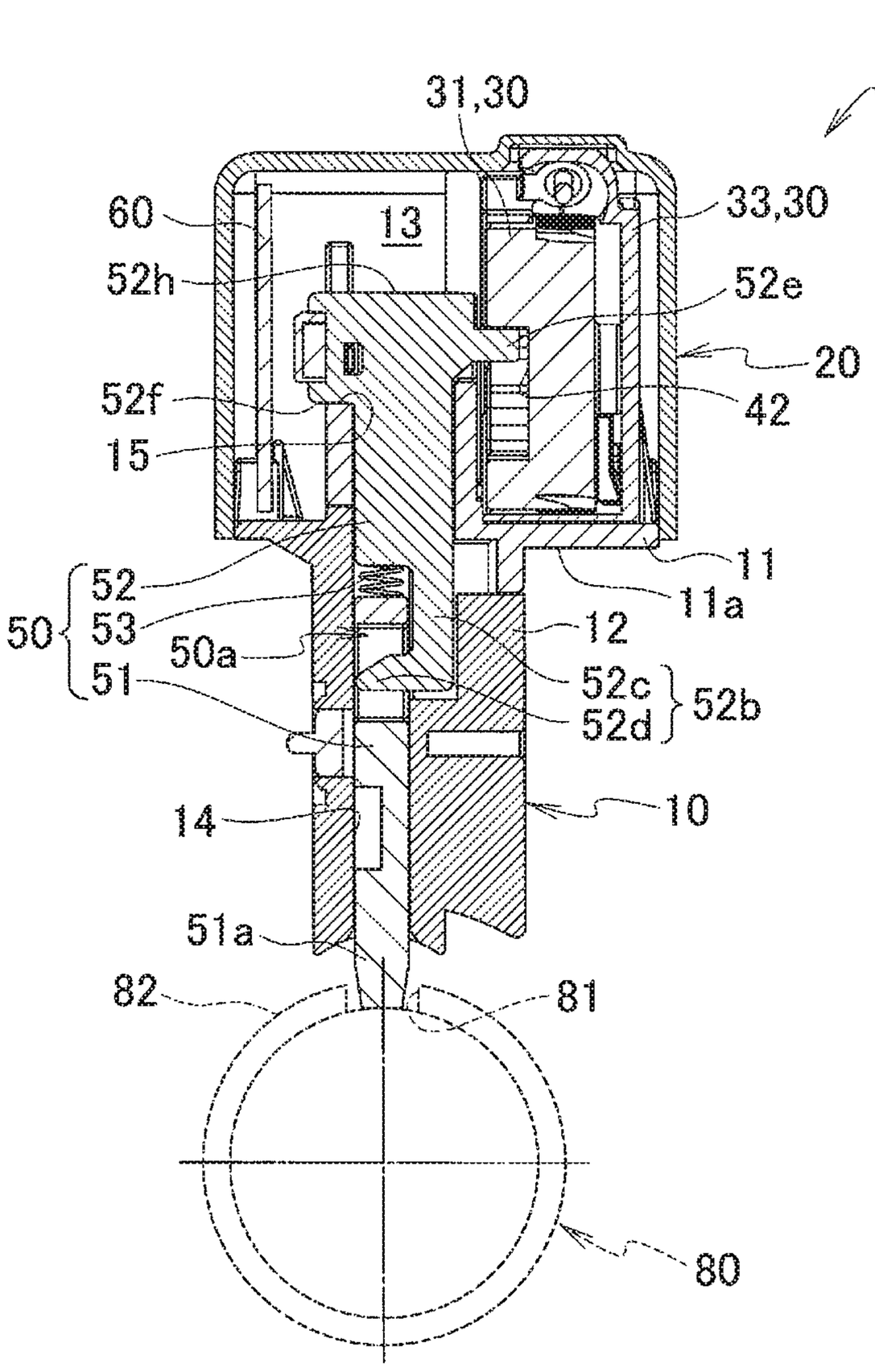


FIG. 5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60
13
33,30
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52e
20
52f
42
15
11
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11a
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53
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52c
52b
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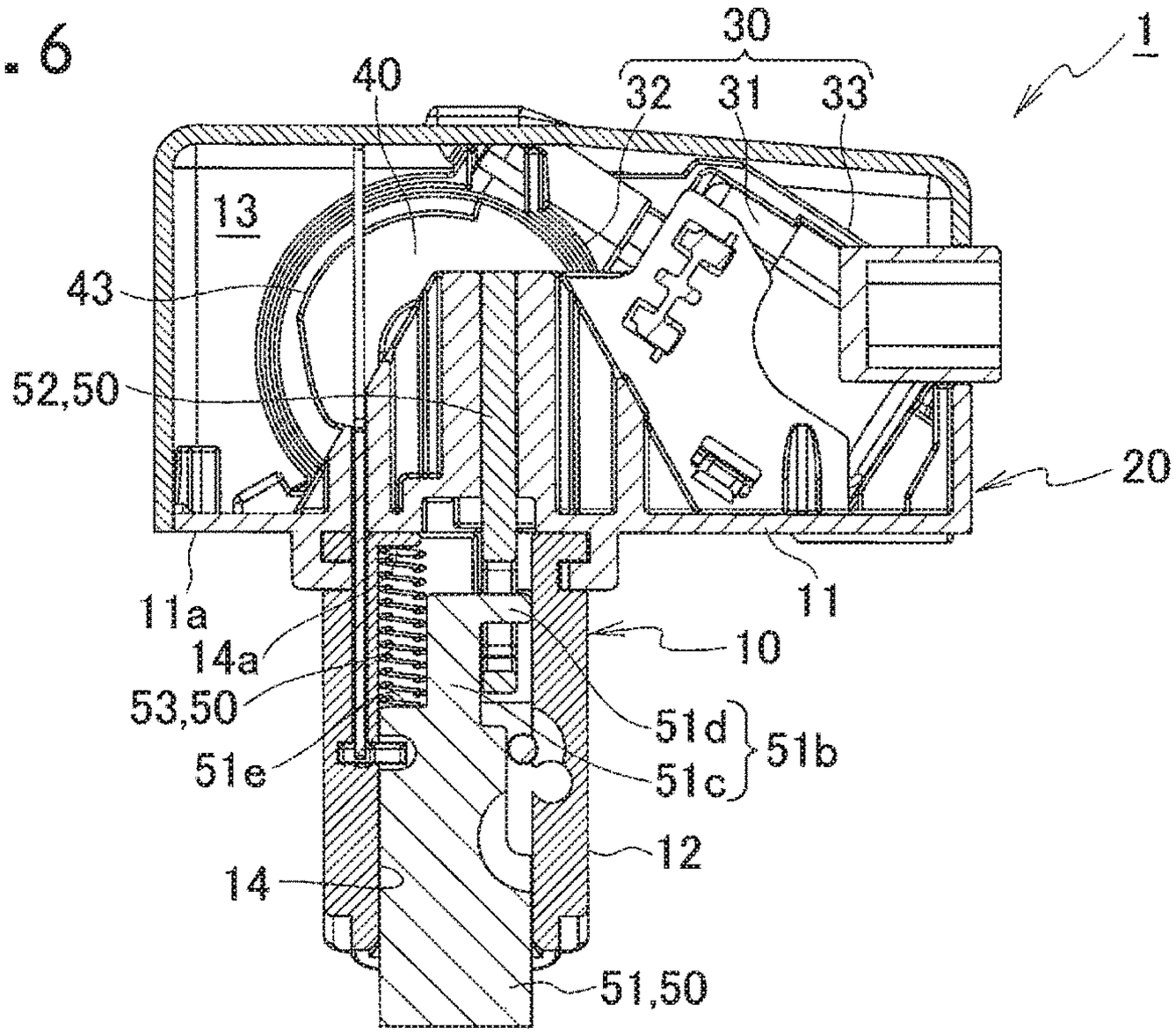
52d
14
10
51a
82
81
80

FIG. 6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13
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11a
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10
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51d
51b
51e
51c
12
14
51,50

FIG. 7

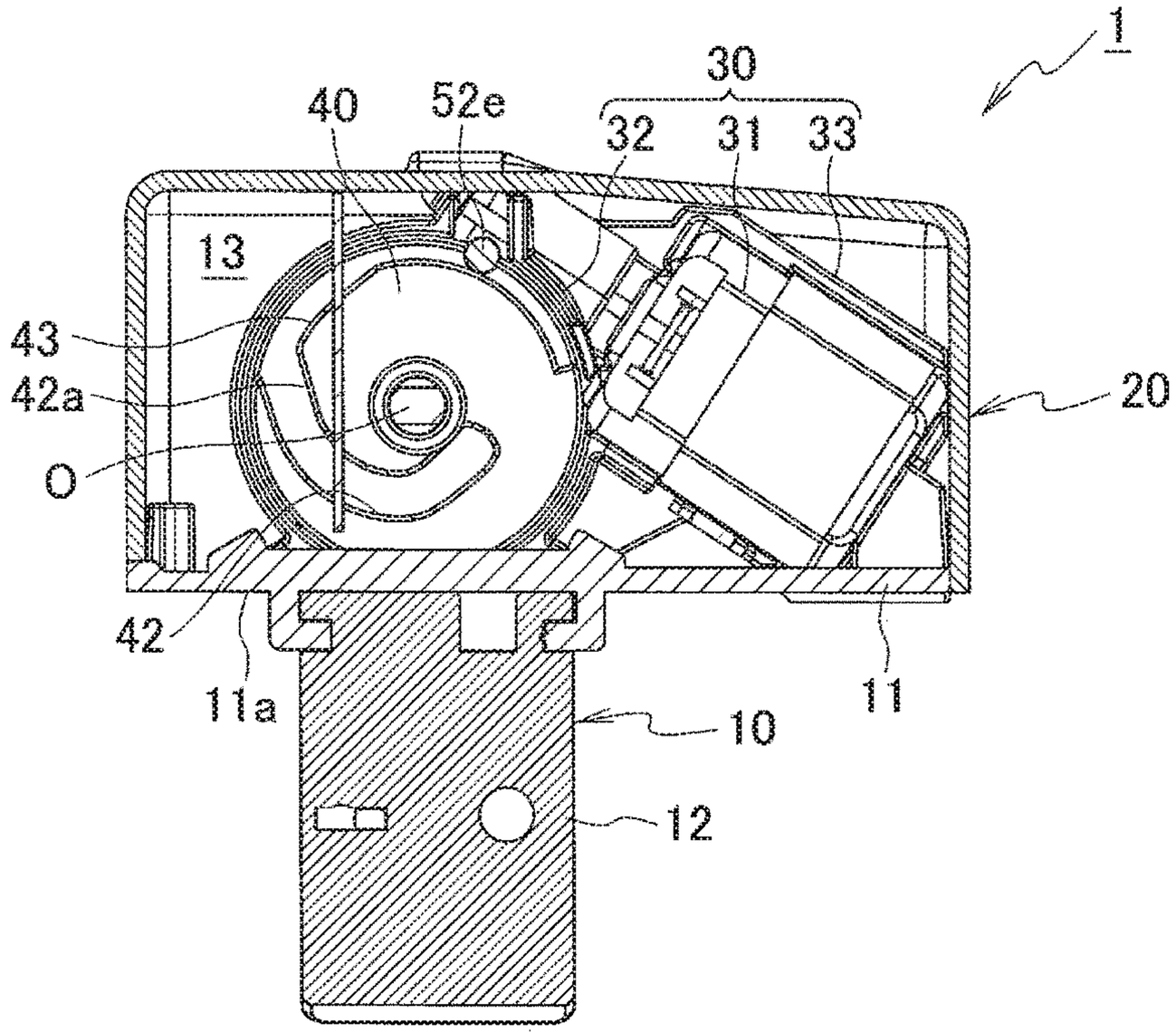
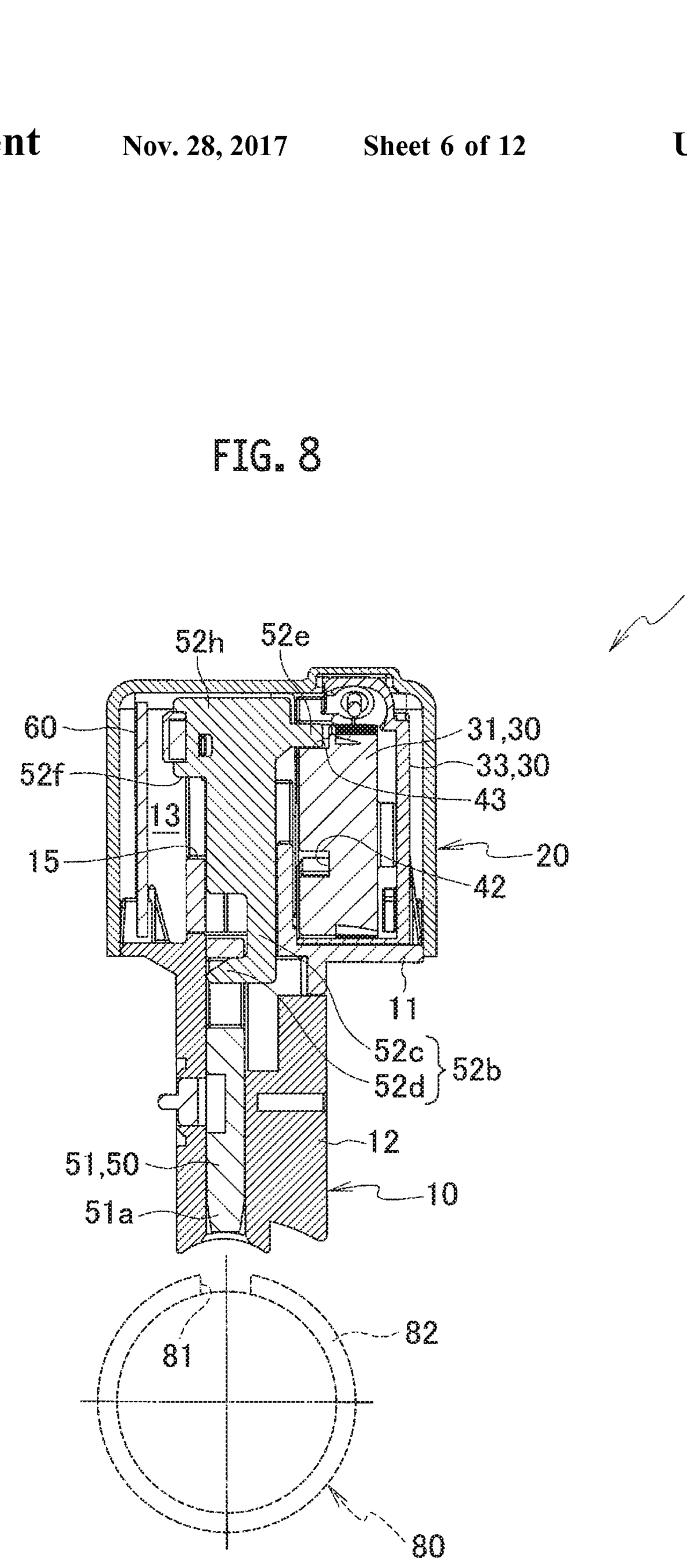

1
30
40
52e
32
31
33
13
43
42a
20
O
42
11
11a
10
12

FIG. 8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52c
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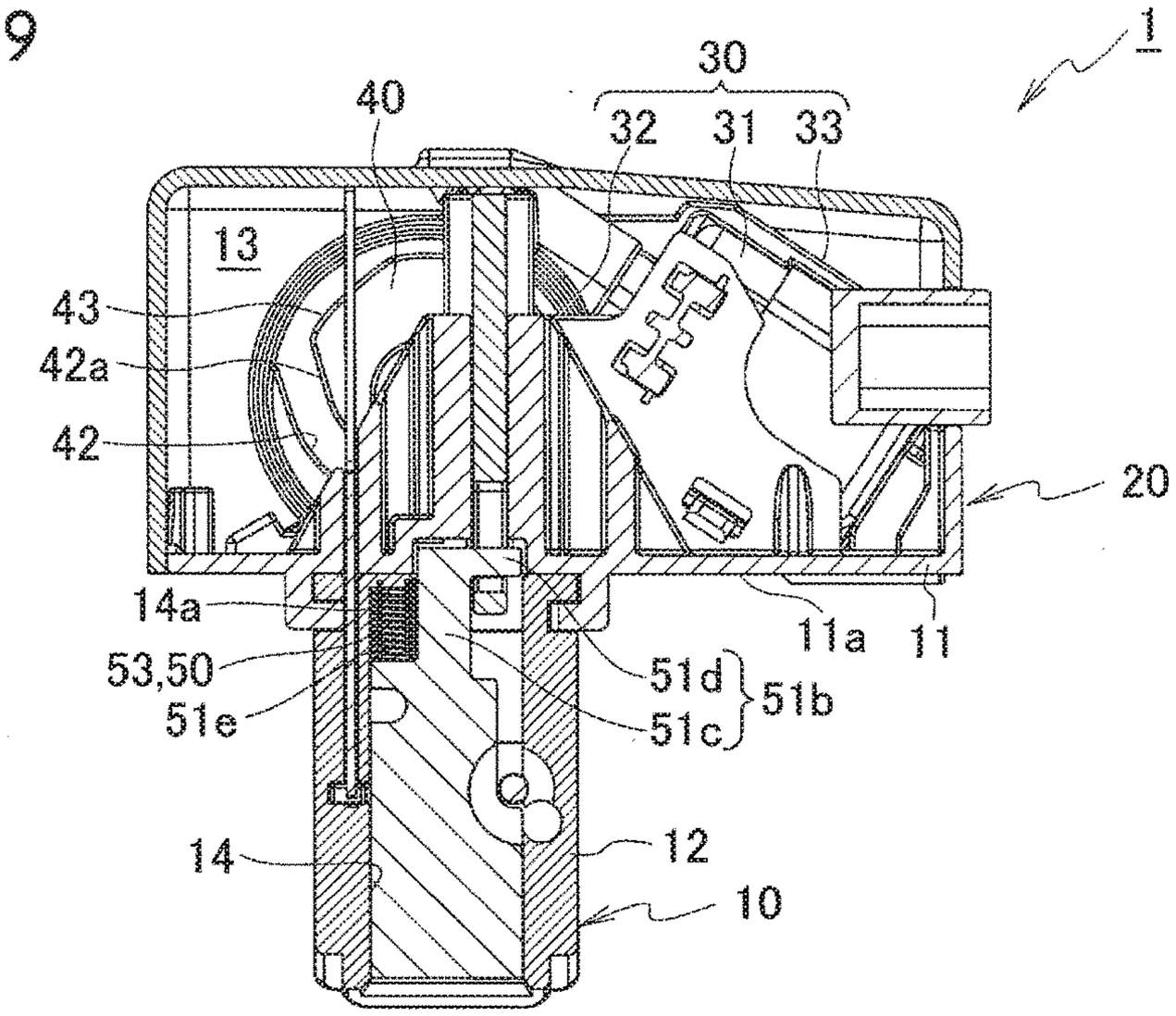
51,50
10
51a
81
82
80

FIG. 9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30
40
32
31
33
13
43
42a
42
20
14a
11a
11
53,50
51d
51b
51e
51c
14
12
10

FIG. 10

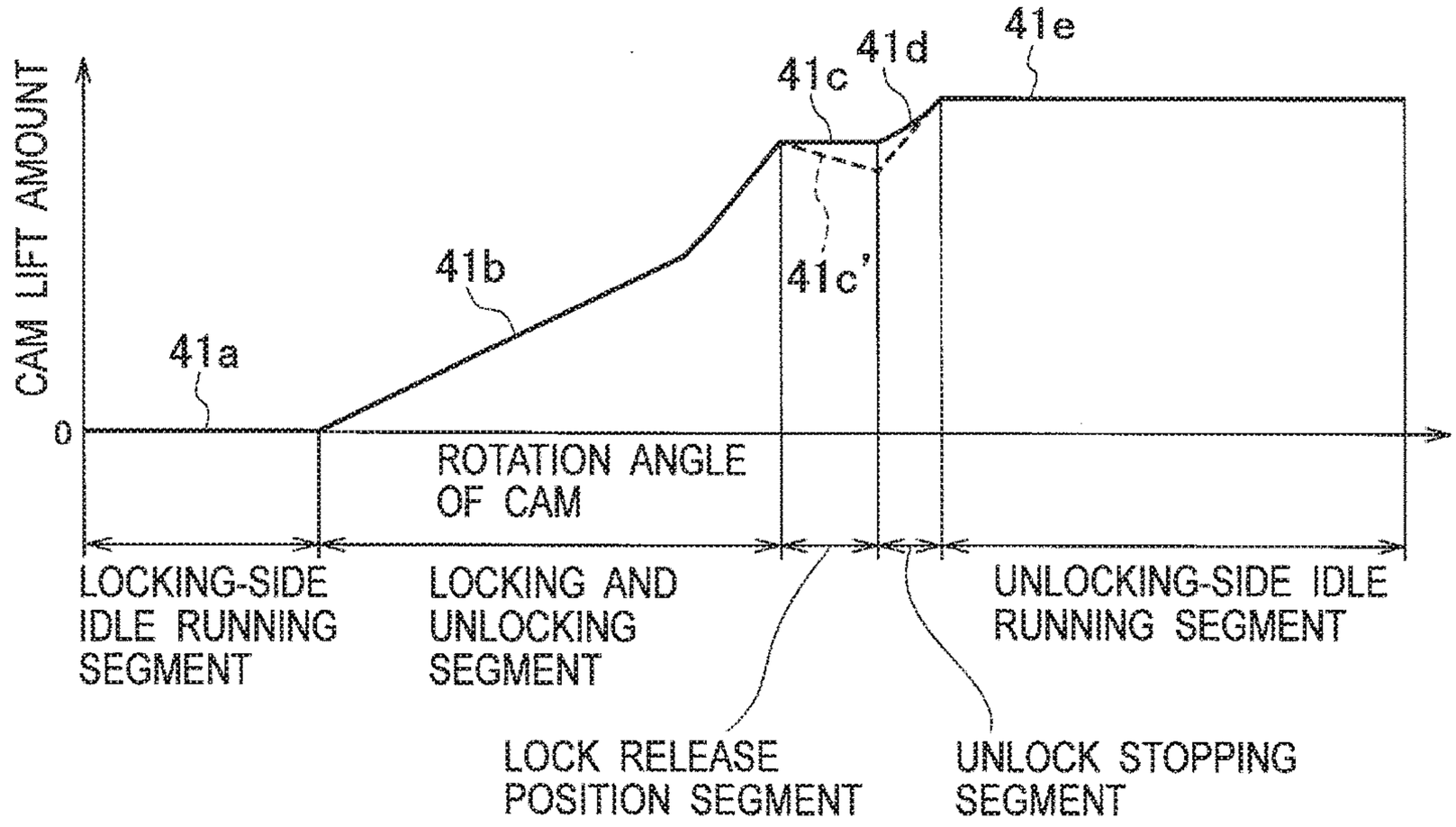

CAM LIFT AMOUNT
0
41a
41b
41c
41c'
41d
41e
ROTATION ANGLE OF CAM
LOCKING-SIDE IDLE RUNNING SEGMENT
LOCKING AND UNLOCKING SEGMENT
UNLOCKING-SIDE IDLE RUNNING SEGMENT
LOCK RELEASE POSITION SEGMENT
UNLOCK STOPPING SEGMENT

FIG. 11

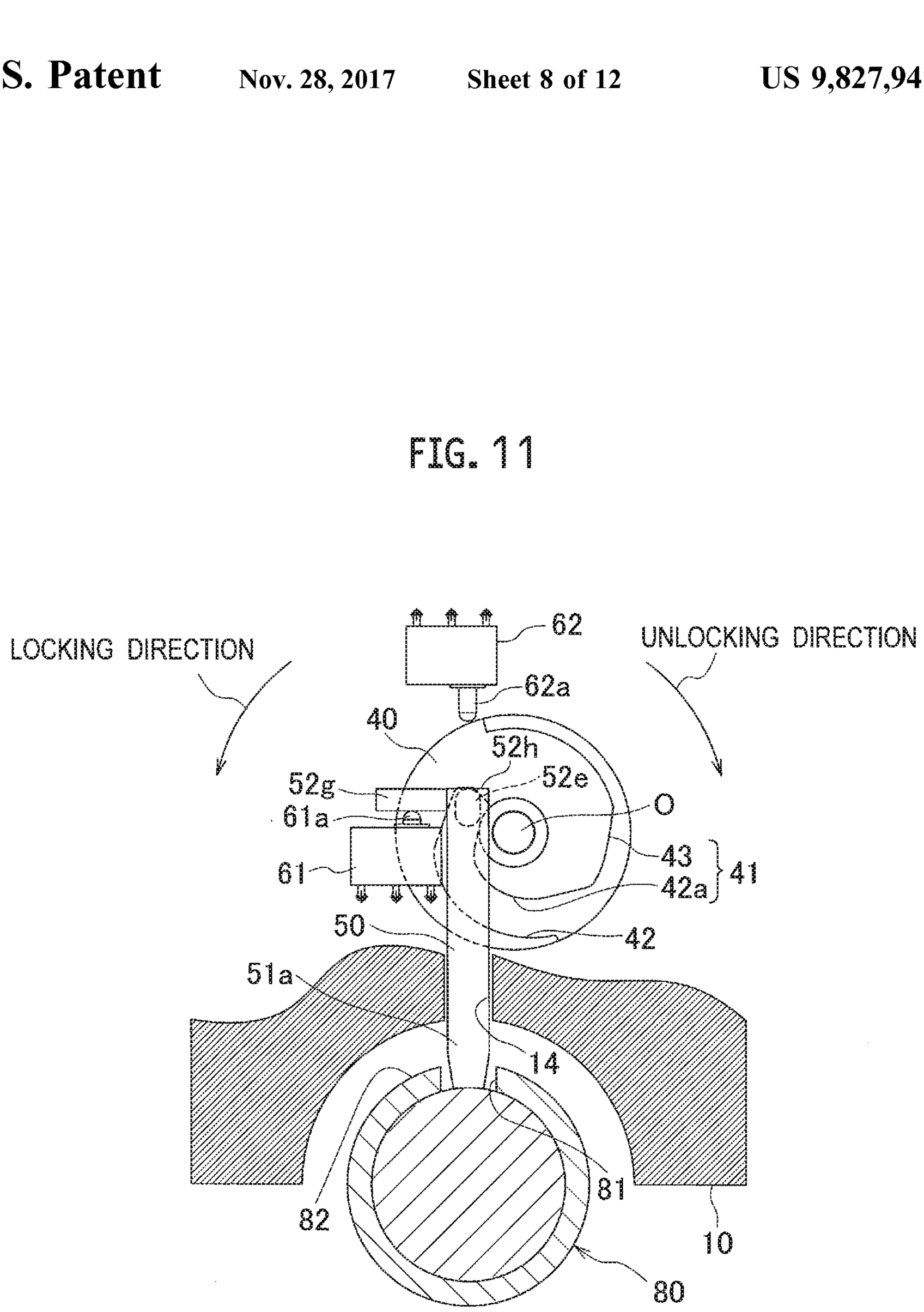

LOCKING DIRECTION
UNLOCKING DIRECTION
62
62a
40
52h
52e
52g
61a
O
61
43
41
42a
50
42
51a
14
81
82
10
80

FIG. 12

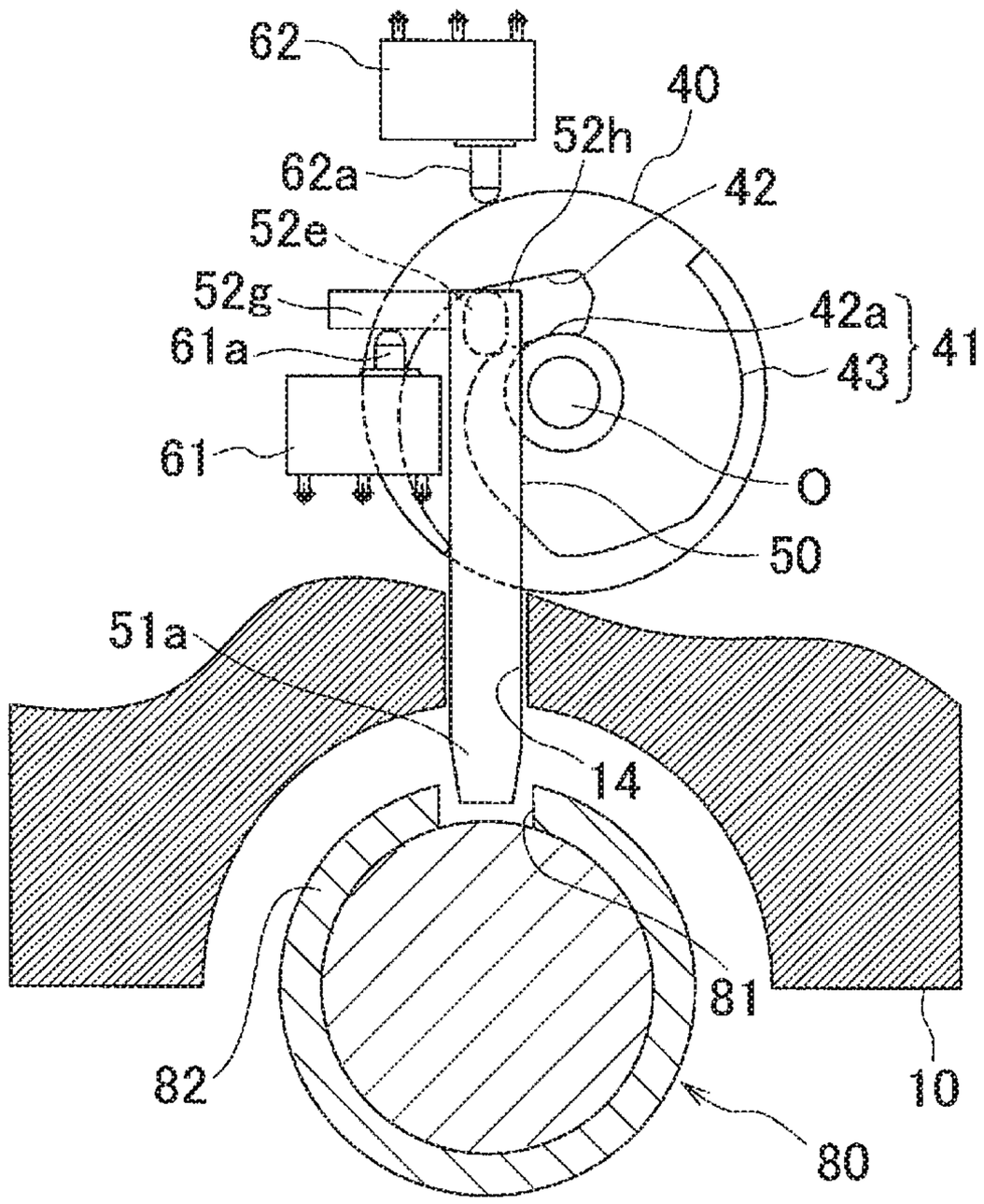


FIG. 13

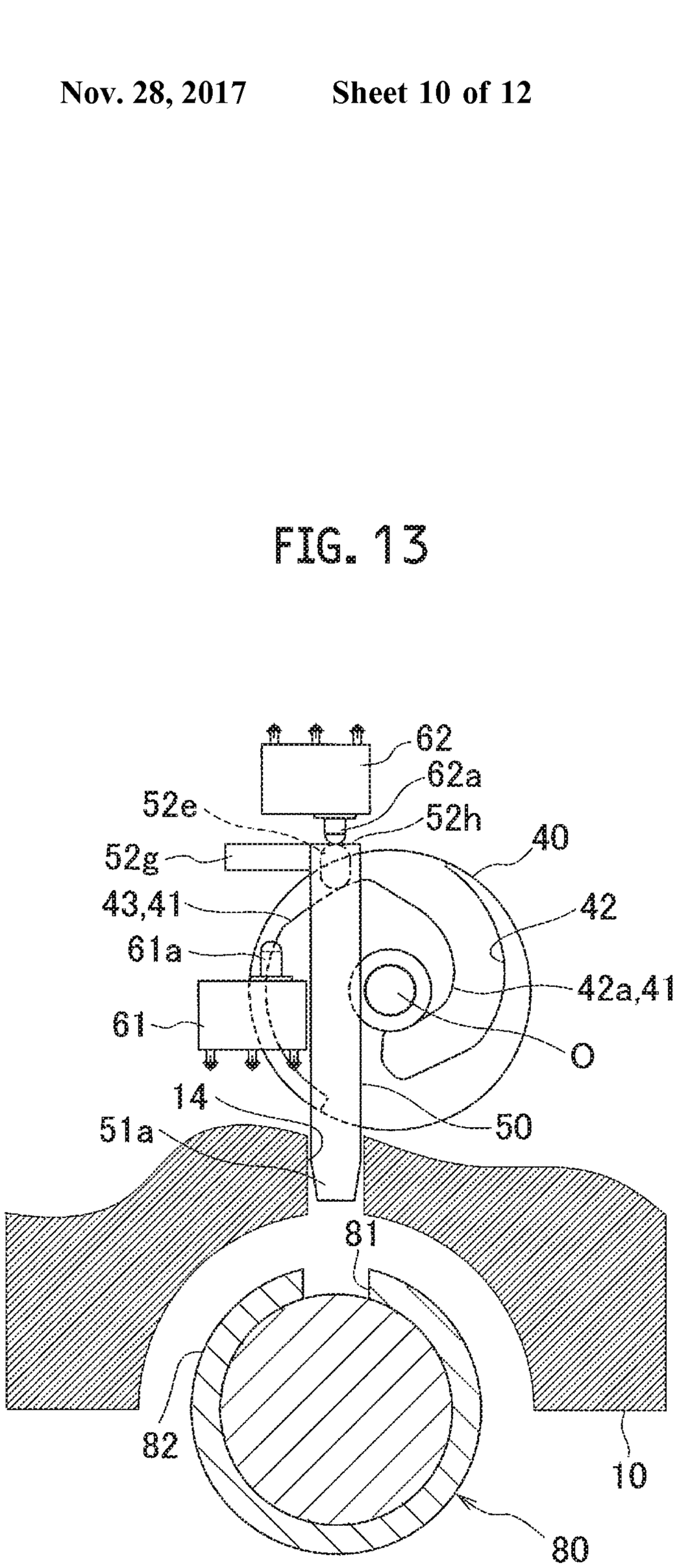


FIG. 14

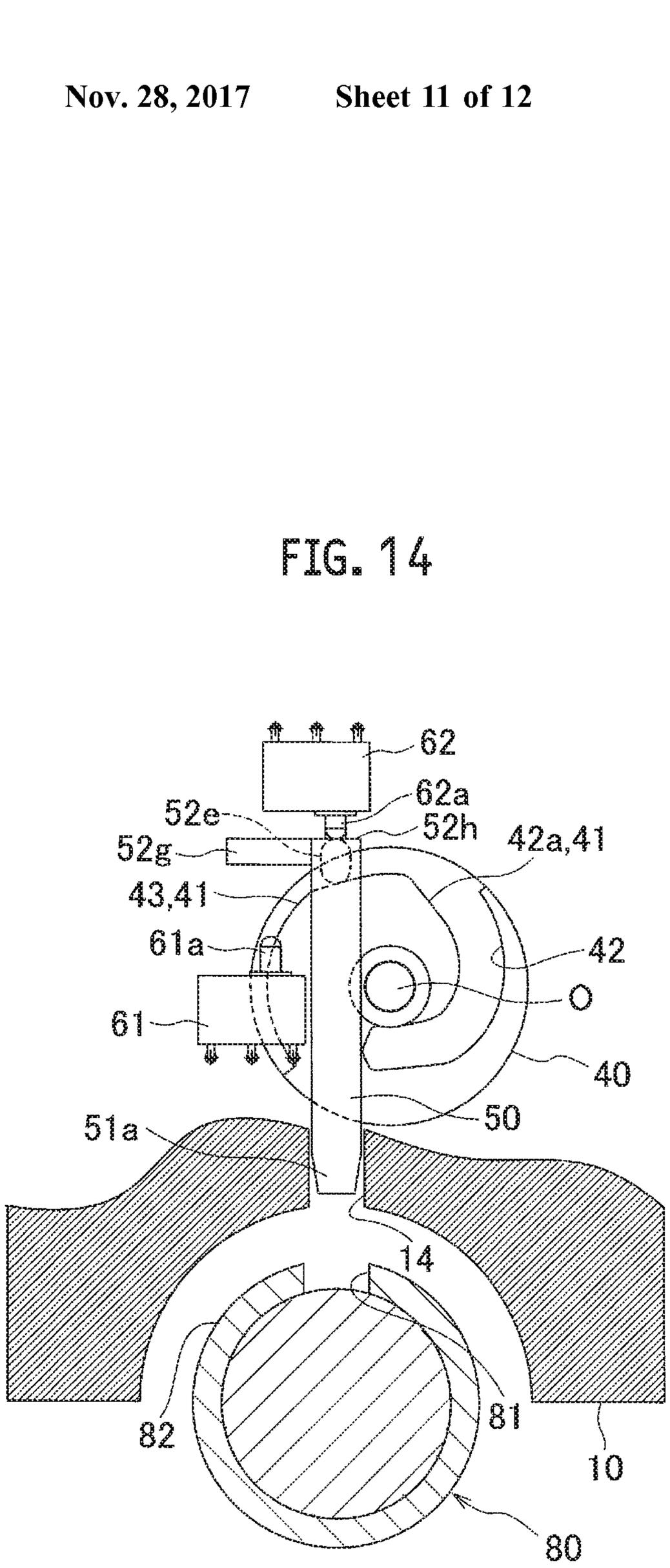
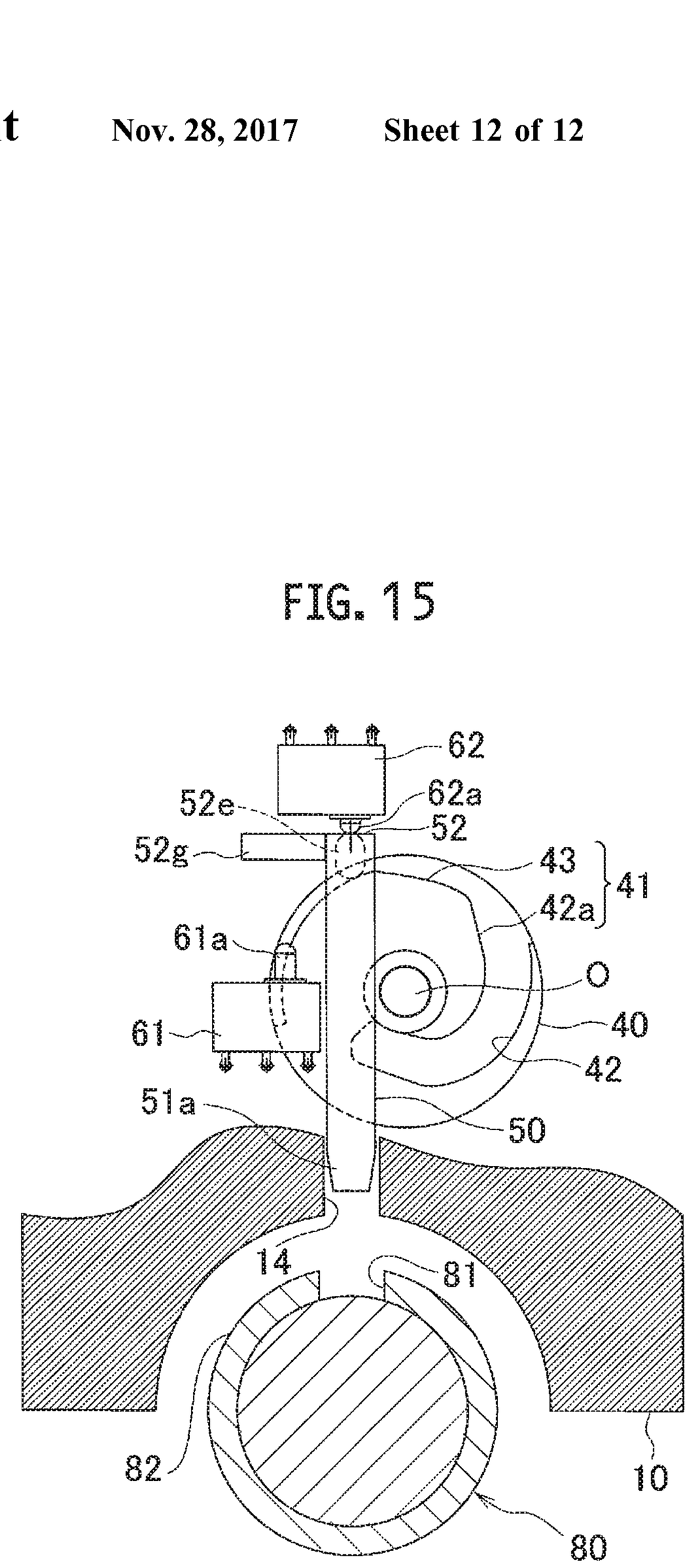


FIG. 15



ELECTRIC STEERING LOCK DEVICE

This is a National Phase Application filed under 35 U.S.C. 371 as a national stage of PCT/JP2014/073471, filed Sep. 5, 2014, an application claiming the benefit of Japanese Application No. 2013-208926, filed Oct. 4, 2013, the content of each of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present invention relates to an electric steering lock device which limits rotation of a steering shaft of a vehicle.

BACKGROUND

As this type of a conventional electric steering lock device, one that is disclosed in Japanese Patent Application Laid-Open Publication No. 2009-35163 (Patent Literature 1) is known. FIG. **1** shows a structure of an electric steering lock device described in Patent Literature 1. This electric steering lock device **101** is provided with a lock member **150** for prohibiting rotation of a steering shaft **180**. Moreover, the lock member **150** is movably arranged between a locked position at which a tip **151***a* of the lock member **150** protrudes from a frame **110** and an unlocked position at which the tip **151***a* of the lock member **150** is accommodated inside of the frame **110**. Further, the electric steering lock device **101** is provided with a cam **140** that rotates integrally with a gear wheel **132**, and the lock member **150** is biased and held on a cam face **141** of the cam **140** by a biasing member (not shown). Thus, by following the rotation of the gear wheel **132**, the lock member **150** moves between the locked position and the unlocked position, while sliding on the cam face **141**.

LITERATURE LIST

Patent Literature

Patent literature 1: Japanese Patent Application Laid-Open Publication No. 2009-35163

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

Incidentally, in the electric steering look device **101** such as one described above, a detection switch (not shown) which detects that the lock member **150** is positioned at the unlocked position is necessary to stop rotation of the gear wheel **132**.

When the detection switch is installed relative to the lock member **150**, it has a structure in which the lock member **150** turns on the detection switch when the lock member **150** has moved to the unlocked position thereby stopping rotation of the cam **140**. In an unlocked state in such a structure, since the lock member **150** is held on an inclined surface of the cam face **141** in a biased state by the biasing member, there is a possibility that the cam **140** may rotate toward the locking direction for some reason.

To solve such a problem, in the above conventional electric steering lock device **101**, a piezoelectric element **170** is installed. Further, in a state that the lock member **150** is positioned in the unlocked position, rotation of the cam **140** toward the locking side is restricted by the friction force by pressing a protrusion **171** of the piezoelectric element **170** onto the cam face **141**.

However, in the above-described conventional electric steering lock device **101**, in a case that the piezoelectric element **170** becomes damaged for some reason, the piezoelectric element **170** is unable to press the cam **140**, and thus, the problem is not solved.

The present invention considers the above circumstances and aims to provide an electric steering lock device which can restrict rotation of the cam in an unlocked state toward the locking direction without providing separate parts, in a state that the lock member is positioned in the unlocked position.

Means to Solve the Problem

In order to achieve the above purpose, a first aspect of the present invention provides an electric steering lock device, which includes a cam arranged to allow forward rotation and reverse rotation inside of a frame; and a lock member which, while following a cam face of the rotating cam, is arranged to be movable forward and backward between a locked position at an advancing end and an unlocked position at a retreating end, in which the cam face includes: a locking and unlocking segment for moving the lock member between the locked position and the unlocked position; and a lock release position segment in which the lock member is held in the unlocked position, and in which a change ratio of a cam lift amount to a rotation angle of the cam in the lock release position segment is constructed to be smaller than the change ratio of the cam lift amount to the rotation angle of the cam in the locking and unlocking segment.

The cam face may be constructed to have the change ratio in the lock release position segment that is constant.

A position detection device that detects that the lock member is positioned at the unlocked position may be arranged between the frame and the lock member.

The cam face may have an unlock stopping segment that is constructed to have the change ratio that is larger than the change ratio in the lock release position segment, and the locking and unlocking segment, the lock release position segment, and the unlock stopping segment may be arranged in the order of the locking and unlocking segment, the lock release position segment, and the unlock stopping segment.

Advantageous Effect of the Invention

According to the first aspect of the present invention, by setting the cam face such that the change ratio of the cam lift amount to the rotation angle of the cam in the lock release position segment is smaller than the change ratio in the locking and unlocking segment, the cam does not rotate toward the locking direction in a state that the lock member is positioned in the unlocked position. Thus, it is possible to restrict rotation of the cam without providing separate parts.

In a case that the cam face is constructed such that the change ratio of the cam lift amount to the rotation angle of the cam in the lock release position segment is made constant, the locking and unlocking segment and the lock release position segment can be made smoothly continuous. Thus, it is possible to reduce an occurrence of tapping sound when the lock member that follows the cam face is displaced between the locking and unlocking segment and the lock release position segment.

In a case that it is made to have a structure in which the position detection device detects that the lock member is

positioned in the unlocked position, it is possible to accurately grasp the position of the lock member. Thus, even in a case that the linkage between the cam and the lock member has come off, it is possible to prevent that a locked state is erroneously determined as an unlocked state.

In a case that it is made to have a structure in which the unlock stopping segment is provided to have the change ratio in the unlock stopping segment that is larger than the change ratio in the lock release position segment, and it is arranged in the order of the locking and unlocking segment, the lock release position segment, and the unlock stopping segment, it becomes possible that rotation of the cam toward the unlocking direction can be stopped within the unlock stopping segment. Thus, in the unlocked state, the lock member can be held at a position that is more retreated than the unlocked position inside of the frame.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an outline cross sectional view showing an electric steering lock device according to conventional technology.

FIG. **2** shows one embodiment of the present invention and is a plan view showing an electric steering lock device.

FIG. **3** shows one embodiment of the present invention and is a front view showing the electric steering lock device.

FIG. **4** is a cross sectional view taken along line **4**-**4** of FIG. **2** in a locked state.

FIG. **5** is a cross sectional view taken along line **5**-**5** of FIG. **3** in a locked state.

FIG. **6** is a cross sectional view taken along line **6**-**6** of FIG. **2** in a locked state.

FIG. **7** is a cross sectional view taken along line **4**-**4** of FIG. **2** in an unlocked state.

FIG. **8** is a cross sectional view taken along line **5**-**5** of FIG. **3** in an unlocked state.

FIG. **9** is a cross sectional view taken along line **6**-**6** of FIG. **2** in an unlocked state.

FIG. **10** is a cam displacement diagram showing a relationship between a cam rotation angle and a cam lift amount.

FIG. **11** is an outline cross sectional view showing a principal part of the embodiment in a state that a following protrusion is positioned in a locking-side idle running segment.

FIG. **12** is an outline cross sectional view showing a principal part of the embodiment in a state that the following protrusion is positioned in a locking and unlocking segment.

FIG. **13** is an outline cross sectional view showing a principal part of the embodiment in a state that the following protrusion is positioned in a lock release position segment.

FIG. **14** is an outline cross sectional view showing a principal part of the embodiment in a state that the following protrusion is positioned in a lock release stopping segment.

FIG. **15** is an outline cross sectional view showing a principal part of the embodiment in a state that the following protrusion is positioned in a lock release-side idle running segment.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Hereinafter, an embodiment of the present invention will be explained by referring to the drawings. A steering lock device according to this embodiment is attached to a steering column device (not shown) which accommodates a steering shaft **80** of a vehicle by a fixing device (not shown), as an electric steering lock device **1**. The electric steering lock device **1** is primarily composed of a frame **10**, a frame cover **20**, a drive device **30**, a lock member **50**, and a control board **60**, as shown in FIG. **2**-FIG. **9**.

The frame **10** is provided with a case part **11** having a generally box shape, one face of which (the upper face in FIG. **4**-FIG. **9** or the like) is opened, and a cylindrical guide part **12** arranged on a bottom face **11***a* of the case part **11**. The guide part **12** has a square cylindrical shape that communicates with a housing chamber **13** while opening to face a steering shaft **80** on its tip side, and the lock member **50** is accommodated in a guide hole **14** which is a cylinder hole to freely move forward and backward. Moreover, a stopper receiving part **15** which engages with a later-described stopper **52***f* is set at a housing chamber-side opening part of the guide hole **14**.

The frame cover **20** has a box-shape that opens on one face (the lower face in FIG. **4**-FIG. **9** or the like), and is assembled to the frame **10** by an engagement receiving part **21** provided on an inner edge of the opening part engaging with an engagement part **11***b* provided on a peripheral edge of the case part **11** of the frame **10**. Moreover, the frame cover **20** forms the housing chamber **13** inside together with the case part **11** as a housing space. Further, the drive device **30** which drives the lock member **50** and the control board **60** which controls operations of the drive device **30** are accommodated in the housing chamber **13**.

The drive device **30** is composed of an electric motor **31** as a driving source, a worm gear (not shown) arranged on an output axis of the electric motor **31**, and a disc-like worm wheel **32** formed as a gear that can engage with the worm gear. Further, by forward rotation of the electric motor **31**, the worm gear rotates the worm wheel **32** in a lock-release direction, and by reverse rotation of the electric motor **31**, the worm gear rotates the worm wheel **32** in a looking direction. The drive device **30** is accommodated in a motor case **33** in a state that the worm gear is engaged with the worm wheel **32** as a unit, and is arranged in the housing chamber **13** along with the motor case **33**.

The worm wheel **32** is provided with a cam **40** on its one disc face. The cam **40** is composed of a spiral-shaped cam groove **42** and an outer peripheral face **43**, and an inner side wall **42***a* of the cam groove **42** and the outer peripheral face **43** are set as a cam face **41**.

The cam face **41**, as shown by the solid line of FIG. **10**, is composed of a locking-side idle running segment **41***a*, a locking and unlocking segment **41***b*, a lock release position segment **41***c*, an unlock stopping segment **41***d*, and an unlocking-side idle running segment **41***e*, and each segment is continuous in this order. Further, a cam lift amount is a dimension from the rotation center O to the cam face **41**, and in this embodiment, it is set to be the smallest at the locking-side idle running segment **41***a* and the largest at the unlocking-side idle running segment **41***e*. Moreover, a change ratio of the cam lift amount to the rotation angle of the cam **40** in each segment of the cam face **41** is determined to be large or small by making the cam lift amount of the locking-side idle running segment **41***a* as a reference.

The locking-side idle running segment **41***a* corresponds to a locked position of the linked lock member **50**, which is positioned at a center location of the spiral shape in the cam groove **42**, and the cam lift amount is set to be constant (the movement amount of the lock member **50** is zero). In other words, the change ratio of the cam lift amount to the rotation angle of the cam **40** in the locking-side idle running segment **41***a* is set to be zero.

The locking and unlocking segment **41***b* corresponds to a path that the linked lock member **50** moves between the

locked position and the unlocked position. In other words, it is set such that one side of the locking and unlocking segment **41***b* is continuous from the locking-side idle running segment **41***a*, and the other side is continuous from the lock release position segment **41***c* respectively, and the cam lift amount becomes larger as it goes from the locking-side idle running segment **41***a* toward the lock release position segment **41***c*. Further, the change ratio of the cam lift amount to the rotation angle of the cam **40** in the locking and unlocking segment **41***b* is set to be different on the locked position side and on the unlocked position side of the locking and unlocking segment **41***b*. The change ratio on the locked position side in the locking and unlocking segment **41***b* is set such that the change ratio becomes relatively small so that a pull-out torque becomes large since an engagement part **51***a* at the tip of the lock member **50** moves backward from an engaged state with an engagement groove **81** at the time of unlocking operation. The change ratio on the unlocked position side in the locking and unlocking segment **41***b* is set to be larger than the locked position side so that it moves backward quickly at the time of unlocking operation since the engagement part **51***a* of a lock body **51** is separated from the engagement groove **81**.

The lock release position segment **41***c* corresponds to the unlocked position of the linked lock member **50**, and the cam lift amount is set to be constant (the movement amount of the lock member **50** is zero and the change ratio of the cam lift amount is zero). Moreover, the change ratio of the cam lift amount to the rotation angle of the cam **40** in the lock release position segment **41***c* does not have to be zero, but it is sufficient if it is set to be at least smaller than the change ratio in the locking and unlocking segment **41***b*.

The unlock stopping segment **41***d* is a segment for the linked lock member **50** (hanger **52**) to turn a later-described unlocking detection switch **62**, and it is continuous from the lock release position segment **41***c*. The change ratio of the cam lift amount within the unlock stopping segment **41***d* is set to be a dimension that does not damage the unlocking detection switch **62** while considering operation strokes, scattering of the operation strokes, scattering of the assembly positions or the like that are necessary and sufficient for turning on the later-described unlocking detection switch **62**. Further, the change ratio of the unlock stopping segment **41***d* is set such that a torque that is sufficient to operate the unlocking detection switch **62** is generated.

The unlocking-side idle running segment **41***e* is formed on the outer peripheral face **43** of the cam **40** to be continuous from the lock release position segment **41***c*, and the cam lift amount is set to be constant.

The lock member **50**, as shown in FIGS. **5**, **6**, **8**, and **9**, is composed of the lock body **51** whose front end which becomes an advancing-side end engages with the engagement groove **81** provided on an outer peripheral face of the steering shaft **80**, the hanger **52** which is engageably/disengageably linked with a rear end side which becomes a retreating-side end of the lock body **51**, and a lock biasing member **53** which biases the lock body **51** from the retreating end side toward the advancing end side. Further, the lock body **51** and the hanger **52** which constitute the lock member **50** are slidably arranged in the guide hole **14** of the guide part **12** in a linked state. In other words, a linkage portion **50***a* of the lock body **51** and the hanger **52** is composed of a body-side linkage part **51***b* provided at the rear end of the lock body **51** and a hanger-side linkage part **52***b* provided at the front end of the hanger **52**. Thus, the lock member **50** becomes freely displaced between the locked position which becomes the advancing end and the unlocked position which becomes the retreating end by the drive device **30**. Moreover, in the locked position, the front end of the lock body **51** protrudes from the guide part **12** to engage with the engagement groove **81** to restrict rotation of the steering shaft **80**. Furthermore, in the unlocked position, the front end of the lock body **51** retreats inside of the guide part **12** to be separated from the engagement groove **81** so that rotation of the steering shaft **80** becomes possible.

The lock body **51** is made of a plate-like hard member, and its front end is set as an engagement part **51***a* that engages with the engagement groove **81**, and its rear end is set as the body-side linkage part **51***b* that is linked with the hanger **52**. The body-side linkage part **51***b* is formed into an L-shape with a body-side neck part **51***c* that extends in the sliding direction and a body-side linkage protrusion **51***d* that protrudes from the rear end of the body-side neck part **51***c* to be orthogonal to the sliding direction.

The hanger **52** is composed of a member that has lower load resistance than the lock body **51**. The hanger **52** is provided with the hanger-side linkage part **52***b*, a following protrusion **52***e*, the stopper **52***f*, and a switch arm part **52***g*.

The hanger-side linkage part **52***b* is arranged on the front end of the hanger **52**, and formed into an L-shaped protrusion with a hanger-side neck part **52***c* and a hanger-side linkage protrusion **52***d*.

The hanger-side neck part **52***c* is thinner than other general part of the hanger **52** and extends in the sliding direction of the lock member **50**.

The hanger-side linkage protrusion **52***d* protrudes from the front end of the hanger-side neck part **52***c* to be orthogonal to the sliding direction.

The following protrusion **52***e* is positioned at the rear end of the hanger **52** to protrude toward the worm wheel **32**. The following protrusion **52***e* is arranged inside of the cam groove **42** in a state that the lock member **50** is assembled in the guide hole **14** and the worm wheel **32** is installed in the housing chamber **13**. Further, when the worm wheel **32** makes forward rotation or reverse rotation, the following protrusion **52***e* follows while abutting the cam face **41** by receiving the biasing force of the lock biasing member **53**.

The stopper **52***f* is provided on the rear end side of the hanger **52** to protrude on the back side of the face that the following protrusion **52***e* is arranged. The stopper **52***f* slides with the hanger **52**. Moreover, the stopper **52***f* is formed such that it engages with a stopper receiving part **18** at the locked position with respect to the locking direction.

The switch arm part **52***g*, as shown in FIG. **11**-FIG. **15**, is composed of a square column shaped cantilever beam that extends along a rotary surface of the worm wheel **32** while being orthogonal to the sliding direction of the hanger **52** at the rear end part of the hanger **52**. The switch arm part **52***g* abuts an operation part **61***a* of a later-described locking detection switch **61** and turns on the later-described locking detection switch **61** when the lock member **50** has moved from the unlocked position to the locked position.

The lock biasing member **53** is made of a coil spring and is arranged in a compressed state between a retreating end wall **14***a* of the guide hole **14** and a retreating end **51***e* on the rear face side of the body-side linkage part **51***b*. Further, the hanger **52** and the lock body **51** are biased in a direction of mutually separating each other by the compression reaction force of the lock biasing member **53** while their linked state is retained. Moreover, by such a linkage structure, the lock member **50** is extendable.

The control board **60** externally supplies electric power to the electric motor **31** and performs the control of forward rotation, reverse rotation and stopping. Also, the locking

detection switch **61** and the unlocking detection switch **62** are arranged on the control board **60**. The locking detection switch **61** and the unlocking detection switch **62** are composed of momentary switches that are turned on only while their operation portions are pressed.

The locking detection switch **61** is a switch which detects that the lock member **50** has moved from the unlocked position to the locked position. Also, the locking detection switch **61** is arranged on the control board **60** in the vicinity of the stopper receiving part **15** along the sliding direction of the lock member **50** (hanger **52**).

The unlocking detection switch (position detection device) **62** is a switch which detects that the lock member **50** (hanger **52**) has moved from the locked position to the unlocked position. Also, the unlocking detection switch **62** is arranged on the control board **60** on the extension line of the retreating end side along the sliding direction of the lock member **50** (hanger **52**).

Next, with the above structure, operations of the electric steering lock device **1** will be explained. First, as shown in FIG. **4**-FIG. **6**, in the electric steering lock device **1** with the lock member **50** being held in the locked position, the lock body **51** protrudes from the guide part **12**. Thus, the engagement part **51***a* of the lock body **51** engages with the engagement groove **81** of the steering shaft **80** and restricts rotation of the steering shaft **80**.

Then, when an unlocking signal is inputted from the vehicle body side to the electric steering lock device **1** in the locked state, the control board **60** supplies electric power to forward-rotate the electric motor **31**. When the electric motor **31** is forward-rotated, the worm wheel **32** rotates in the unlocking direction (clockwise in FIG. **11**) through the worm gear. When the worm wheel **32** rotates in the unlocking direction, as shown in FIG. **11**-FIG. **15**, the following protrusion **52***e* follows on the cam face **41** in the order of the locking and unlocking segment **41***b*, the lock release position segment **41***c*, and the unlock stopping segment **41***d* while resisting the biasing force of the lock biasing member **53**. Thus, the lock member **50** moves from the locked position to the unlocked position.

Further, when the following protrusion **52***e* approaches the unlock stopping segment **41***d*, a retreating end **52***h* of the hanger **52** abuts an operation part **62***a* of the unlocking detection switch **62**, and the unlocking detection switch **62** is turned on. Then, the ON signal of the unlocking detection switch **62** is inputted to the control board **60**, and the electric power from the control board **60** to the electric motor **31** is stopped, and the electric motor **31** is stopped. Thus, the lock member **50** is held in the unlocked position.

Further, at the time of unlocking operation, it is conceivable that the unlocking detection switch **62** is not turned on in the locking and unlocking segment **41***b* for some reason and the following protrusion **52***e* follows on the unlocking-side idle running segment **41***e*. In such a case, since the operation time of the electric motor **31** becomes longer than a set time, the control board **60** determines abnormality and the control board **60** forcibly stops the electric motor **31** within the unlocking-side idle running segment **41***e*.

Moreover, it is conceivable that there is a case in which the lock body **51** is bitten in the engagement groove **81** and cannot be moved to the unlocked position. In such a case also, since the operation time of the electric motor **31** becomes longer than a set time, the control board **60** determines abnormality and the control board **60** forcibly stops the electric motor **31**.

In the electric steering lock device **1** in the unlocked state, as shown in FIG. **7**-FIG. **9**, the lock body **51** is positioned in the unlocked position that is drawn inside of the guide hole **14**. Thus, the engagement between the engagement part **51***a* of the lock body **51** and the engagement groove **81** of the steering shaft **80** is released, and rotation of the steering shaft **80** becomes possible. Further, the following protrusion **52***e* is positioned in the unlock stopping segment **41***d* of the cam face **41**. That is, the lock member **50** is held at a position that is further retreated from the unlocked position.

Incidentally, the unlock stopping segment **41***d* is set such that its cam lift amount becomes smaller as it goes toward the lock release position segment **41***c*. Thus, in a case that the engagement between the worm wheel **32** and the worm gear comes off for some reason, it is conceivable that the worm wheel **32** may rotate toward the locking direction by the biasing force of the lock biasing member **53** and the following protrusion **52***e* may move to the lock release position segment **41***c*.

However, even if the following protrusion **52***e* moves to the lock release position segment **41***c* from the unlock stopping segment **41***d*, since the change ratio of the cam lift amount in the lock release position segment **41***c* is zero, it does not move to the locking and unlocking segment **41***b*. In other words, it has a structure in which even if the engagement between the worm wheel **32** and the worm gear comes off for some reason, the lock member **50** does not advance to the locked position side by the biasing force of the lock biasing member **53** than the unlocked position.

Next, when a locking signal is inputted to the electric steering lock device **1** in the unlocked state from the vehicle body side via the control board **60**, the control board **60** supplies electric power to reverse-rotate the electric motor **31**. Then, when the electric motor **31** is reverse-rotated, the worm wheel **32** rotates in the locking direction (counterclockwise in FIG. **11**) through the worm gear. When the worm wheel **32** rotates in the locking direction, the following protrusion **52***e* follows on the cam face **41** in the order of the unlock stopping segment **41***d*, the lock release position segment **41***c*, and the locking and unlocking segment **41***b* by the biasing force of the lock biasing member **53**, and the lock member **50** moves from the unlocked position to the locked position.

When the lock member **50** reaches the locked position while following on the locking and unlocking segment **41***b*, the switch arm part **52***g* abuts the operation part **61***a* of the locking detection switch **61**, and the locking detection switch **61** is turned on. Then, the ON signal of the locking detection switch **61** is inputted to the control board **60**, and the electric power from the control board **60** to the electric motor **31** is stopped and the electric motor **31** is stopped. Thus, the lock member **50** is held in the locked position. As shown in FIG. **4**-FIG. **6**, in the electric steering lock device **1** in which the lock member **50** is held in the locked position, the engagement part **51***a* of the lock body **51** engages with the engagement groove **81** of the steering shaft **80** and restricts rotation of the steering shaft **80**.

In a case that the engagement part **51***a* of the lock body **51** runs onto a protrusion portion **82** that constitutes the engagement groove **81** of the steering shaft **80** when it moves to the locked position, the lock biasing member **53** is compressed to shrink and the hanger **52** moves to the locked position in a state that the lock body **51** remains to run on the protrusion portion **82**. Then, when the steering shaft **80** rotates and the protrusion portion **82** slips off from the engagement part **51***a* of the lock body **51**, the engagement part **51***a* engages with the engagement groove **81** by the biasing force of the lock biasing member **53** to restrict rotation of the steering shaft **80**.

Further, there is a possibility that the lock body **51** engages with the engagement groove **81** before the locking detection switch **61** is turned on because of scattering of the operation strokes of the locking detection switch **61** and scattering of the assembly positions. In such a case also, since the lock member **51** is pressed against the bottom part of the engagement groove **81** and the lock biasing member **53** is compressed to shrink, while the hanger **52** advances, disadvantage does not occur.

Moreover, it is conceivable that the locking detection switch **61** is not turned on in the locking and unlocking segment **41***b* for some reason, and the following protrusion **52***e* follows on the locking-side idle running segment **41***a*. In such a case, since the operation time of the electric motor **31** becomes longer than a set time, the control board **60** determines abnormality and the control board **60** forcibly stops the electric motor **31** within the locking-side idle running segment **41***a*. Furthermore, the stopper **52***f* abuts the stopper receiving part **15**, and restricts the lock member **50** from advancing further from the locked position.

With the above structure, in this embodiment, by setting the cam face **41** such that the cam lift amount in the lock release position segment **41***c* is made constant and the change ratio of the cam lift amount to the rotation angle of the cam **40** in the lock release position segment **41***c* is smaller than the change ratio in the locking and unlocking segment **41***b*, the cam **40** does not rotate toward the locking direction in a state that the lock member **50** is positioned in the unlocked position. Thus, it is possible to restrict rotation of the cam **40** without providing separate parts.

Moreover, by constructing the cam face **41** such that the cam lift amount in the lock release position segment **41***c* is made constant, the locking and unlocking segment **41***b* and the lock release position segment **41***c* can be made smoothly continuous. Thus, it is possible to reduce an occurrence of tapping sound when the lock member **50** that follows the cam face **41** is displaced between the locking and unlocking segment **41***b* and the lock release position segment **41***c*.

By having a structure in which the unlocking detection switch (position detection device) **62** detects that the lock member **50** is positioned in the unlocked position, it is possible to accurately grasp the position of the lock member **50**. Thus, even in a case that the linkage between the cam **40** and the lock member **50** has come off, it is possible to prevent that a locked state is erroneously determined as an unlocked state.

By having a structure in which the change ratio in the unlock stopping segment **41***d* is larger than the change ratio in the lock release position segment **41***c*, and it is arranged in the order of the locking and unlocking segment **41***b*, the lock release position segment **41***c*, and the unlock stopping segment **41***d*, it is possible that rotation of the cam **40** toward the unlocking direction can be stopped at a position that the lock member **50** is more retreated than the unlocked position. Thus, in the unlocked state, the lock member **50** can be held at a position that is more retreated than the unlocked position inside of the frame **10**.

Further, in this embodiment, as shown by the solid line of FIG. **10**, the cam face **41** is structured such that the cam lift amount in the lock release position segment **41***c* is constant; however, as shown by the broken line of FIG. **10**, the cam face **41** may also be structured such that the cam lift amount in the lock release position segment **41***c*' becomes smaller as the rotation angle of the cam increases. In a case that it is structured as such, when rotation of the worm wheel **32** toward the locking direction becomes freely possible for some reason, and the worm wheel **32** rotates to move the following protrusion **52***e* from the unlock stopping segment **41***d* to the lock release position segment **41***c* by the biasing force of the lock biasing member **53**, in order for the following protrusion **52***e* to move further from the lock release position segment **41***c* to the locking and unlocking segment **41***b*, the cam **40** has to rotate toward the locking direction while resisting the biasing force of the lock biasing member **53**. Since such rotation is not possible without motive power, it is possible to prevent the lock member **50** from unexpectedly moving to the locked position further as compared with this embodiment, and it is possible to further improve security as compared with this embodiment.

In addition, in such a structure, when the following protrusion **52***e* moves from the locking and unlocking scent **41***b* to the lock release position segment **41***c*, there is a case in which tapping sound occurs by the following protrusion **52***e* not being able to follow on the cam face **41** and bouncing at the border portion of the both segments. Thus, it may also be made to have a structure to inform an operator that the electric steering lock device **1** has been unlocked by the unlocking operation by generating the tapping sound such that the operator can hear it.

Furthermore, in this embodiment, the momentary switch is used as the unlocking detection switch (position detection device), but it is not limited to this, and a structure that uses various sensors is possible in order to achieve similar operations and advantageous effects.

What is claimed is:

1. An electric steering lock device, comprising:

a cam arranged to allow forward rotation and reverse rotation inside of a frame;

a lock member which, while following a cam face of the rotating cam, is arranged to be movable forward and backward between a locked position at an advancing end and an unlocked position at a retreating end, and

a position detection device that detects that the lock member is positioned at the unlocked position is arranged between the frame and the lock member,

wherein the cam face comprises:

a locking and unlocking segment for moving the lock member between the locked position and the unlocked position;

a lock release position segment in which the lock member is held in the unlocked position; and

an unlock stopping segment that is constructed to have the change ratio of a cam lift amount that is larger than the change ratio of the cam lift amount in the lock release position segment,

wherein the locking and unlocking segment, the lock release position segment, and the unlock stopping segment are arranged in the order of the locking and unlocking segment, the lock release position segment, and the unlock stopping segment,

wherein a change ratio of the cam lift amount to a rotation angle of the cam in the lock release position segment is constructed to be zero,

wherein the unlock stopping segment is a segment to operate the position detection device, the change ratio of the cam lift amount to the rotation angle of the cam in the unlock stopping segment is set to operate a cam follower operatively connected to the lock member so that the lock member, according to the rotation angle of the cam, operates the position detection device.

2. An electric steering lock device, comprising:

a cam arranged to allow forward rotation and reverse rotation inside of a frame;

a lock member which, while following a cam face of the rotating cam, is arranged to be movable forward and backward between a locked position at an advancing end and an unlocked position at a retreating end; and

a position detection device that detects that the lock member is positioned at the unlocked position is arranged between the frame and the lock member,

wherein the cam face comprises:

a locking and unlocking segment for moving the lock member between the locked position and the unlocked position;

a lock release position segment in which the lock member is held in the unlocked position, and

an unlock stopping segment that is constructed to have the change ratio of a cam lift amount that is larger than the change ratio of the cam lift amount in the lock release position segment,

wherein the locking and unlocking segment, the lock release position segment, and the unlock stopping segment are arranged in the order of the locking and unlocking segment, the lock release position segment, and the unlock stopping segment,

wherein the cam face has a change ratio of a cam lift amount to a rotation angle of the cam in each segment of the cam face, as determined by a cam lift amount such that the cam lift amount in the lock release position segment becomes smaller as a rotation angle of the cam increases, so that a cam follower operatively connected to the lock member positions the lock member according to the rotation angle of the cam,

and wherein the unlock stopping segment is a segment to operate the position detection device, the change ratio of the cam lift amount to the rotation angle of the cam in the unlock stopping segment is set to operate a cam follower operatively connected to the lock member so that the lock member according to the rotation angle of the cam operates the position detection device.

3. The electric steering lock device according to claim **2**, wherein the cam face has a dimension that a change ratio of the cam lift amount is constant in the lock release position segment.

4. The electric steering lock device according to claim **1**, wherein the cam lift amount in the unlock stopping segment has an operation stroke sufficient for operating the position detection device.

5. The electric steering lock device according to claim **1**, wherein the change ratio of the cam lift amount in the unlock stopping segment is set to generate a torque that is sufficient to operate the position detection device.

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